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FUEL INJECTOR

FIELD OF THE INVENTION

This invention relates to a fuel injector having a solenoid.

BACKGROUND INFORMATION

An electromagnetically operable fuel injector is already known from German Laid-Open Patent No. DE-OS 33 14 899 in which for the purposes of electromagnetic activation an armature acts together with an electrically excitable solenoid and the stroke of the armature is transmitted by way of a valve needle to a valve closing member. The valve closing member works together with a valve seat. The armature is not rigidly attached to the valve needle, but is arranged with axial movement relative to the valve needle. A first return spring exerts pressure on the valve needle in the closing direction and thus holds the fuel injector closed when the solenoid is non-current-bearing and thus not excited. The armature is pressed by a second return spring in the stroke direction such that in its idle position the armature is touching a first stop provided on the valve needle. When the solenoid is excited, the armature is pulled in the stroke direction and by way of the first stop takes the valve needle with it. When the current exciting the solenoid is switched off, the valve needle is accelerated to its closed position by the first return spring, and brings the armature with it by the described stop. As soon as the valve closing member comes into contact with the valve seat, the closing movement of the valve needle is abruptly halted. The movement of the armature, which is not rigidly connected to the valve needle, continues against the stroke direction and is halted by the second return spring, in other words the armature follows through against the second return spring which has a much lower spring constant than the first return spring. Finally, the second return spring accelerates the armature back in the stroke direction.

One disadvantage with the fuel injector known from German Laid-Open Patent No. DE-OS 33 14 899 is the incomplete elimination of bounce, and on the other hand the arrangement of

the armature and valve needle also makes it possible for the latter to tilt or stick as a result of center offset between the valve needle and the armature. This defect is intensified by manufacturing errors in the individual components of the fuel injector, leading to malfunctions of the injector.

In this connection it has also been suggested in U.S. Patent No. 5,295,776 that the armature should not be connected rigidly to the valve needle, but that a certain axial play in the armature relative to the valve needle should be permitted.

The fuel injector shown in U.S. Patent No. 5,299,776, however, is equipped with a flat armature, which is not guided within the injector housing but moves freely along the internal pole of the solenoid. In addition, the valve needle has only one guide sleeve, upon which the return spring is supported. A lower guide function is provided by a guide unit which is connected to the injector housing. This guide unit surrounds the valve needle but is not connected to it in a friction locking manner.

The particular disadvantage of this arrangement lies in the restriction of the degree of freedom in the movement of the valve needle through the guide sleeve joined with the injector housing and thus in the danger of the valve needle tilting. To counter this disadvantage requires that the components are manufactured extremely accurately, and this requires high cost and very complex manufacturing.

<u>SUMMARY OF THE INVENTION</u>

The fuel injector according to the present invention has the advantage relative to the related art on the one hand that the radial and axial play of the valve needle brought about by the two guide sleeves and by the central opening in the armature provide so much freedom of movement that tilting may be impossible, and on the other that the individual components of the fuel injector may be manufactured with a low degree of complexity, and low production costs, for example by deep drawing, since the design according to the present invention presents a very high tolerance for manufacturing errors in the components.

Also advantageous may be the wedge-shaped or spherical design of the guide sleeves, and

the corresponding elevations in the faces of the armature, which compensate for angular misplacements of the valve needle relative to the longitudinal axis of the fuel injector.

In addition, the symmetrical design, i.e. the rotatable mounting of the valve needle in the sealing seat, may be advantageous, since this means that even in the event of major center offsets the valve needle may always align itself optimally.

Through the gaps between the guide sleeves and the armature, in addition, a slight pre-acceleration of the valve needle may be achieved, before the armature lifts the valve needle off the sealing seat. By this means the opening times or the amounts of fuel metered may be improved.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 shows a schematic cross-section through a first exemplary embodiment of a fuel injector according to the present invention.

Figure 2 shows an enlarged schematic cross-section through the fuel injector according to the invention shown in Figure 1 in the area marked as II in Figure 1.

Figure 3 shows an enlarged schematic cross-section through a second exemplary embodiment of a fuel injector according to the invention shown in the area marked as II in Figure 1.

DETAILED DESCRIPTION

A fuel injector 1 may be constructed in the form of a fuel injector for fuel injection systems on spark-ignition internal combustion engines, in which the fuel-air mixture may be compressed. Fuel injector 1 may be particularly suitable for direct injection of fuel into a combustion chamber, not shown, of an internal combustion engine.

Fuel injector 1 may be composed of a nozzle body 2 into which a valve needle 3 is guided. Valve needle 3 acts upon a valve closing member 4, which acts together with a valve seat surface 6 situated on a valve seat body 5 to compose a sealing seat. In fuel injector 1 in the exemplary embodiment the opening action is inwards, and fuel injector 1 has a spray orifice

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Valve needle 3 may be rotatably mounted in the sealing seat in order to permit simple guidance of the needle. This has no impact on the imparting of swirl by fuel injector 1, since valve needle 3 may be symmetrical around its axis of rotation.

Nozzle body 2 may be sealed against external pole 9 of a solenoid 10 by a seal 8. Solenoid 10 may be encapsulated in a solenoid housing 11 and wound around a bobbin 12, which may be touching internal pole 13 of solenoid 10. Internal pole 13 and external pole 9 may be separated from one another by a gap 26 and supported on a connecting member 29. Solenoid 10 may be excited through a wire 19 by an electrical current which may be supplied via an electrical plug contact 17. Plug contact 17 may be surrounded by a plastic sheath 18 which may be sprayed onto internal pole 13.

Valve needle 3 may be guided in a valve needle guide 14, which may be disk-shaped. A matched setting disk 15 may be used to adjust the stroke setting. An armature 20 may be located on the other side of setting disk 15. The armature may be in friction-locking connection with valve needle 3, through first guide sleeve 35, and valve needle 3 in turn may be connected by a weld seam 22 to first guide sleeve 35. Supported on first guide sleeve 35 may be a return spring 23, which in the present design of fuel injector 1 may be pre-tensioned by a sleeve 24. A second guide sleeve 36, which may be connected to valve needle 3 through a weld seam 33, acts as the lower armature stop.

Armature 20 has a central opening 34, through which valve needle 3 protrudes. The radial diameter of central opening 34 may be larger than the diameter of valve needle 3, which results in armature 20 having a radial play relative to valve needle 3. This measure, in conjunction with guide sleeves 35 and 36, ensures that valve needle 3 cannot become tilted or stuck.

A detailed description of the area identified as II in Figure 1 between guide sleeves 35 and 36 is explained more fully in the description covering Figures 2 and 3.

Fuel ducts 30a to 30c run through valve needle guide 14, in armature 20 and on valve seat body 5, bringing the fuel, which may be supplied via a central fuel feed 16 and may be

filtered through a filter element 25, to spray orifice 7. Fuel injector 1 may be sealed off by a seal 28 from a cylinder head not further shown or from a fuel distribution line.

In the idle state of fuel injector 1, valve needle 3 may be pressed by return spring 23 via first guide sleeve 35 against the stroke direction such that valve closing member 4 may be held in sealing contact at valve seat 6. When solenoid 10 is excited, it creates a magnetic field that first pulls armature 20, which is freely movable between guide sleeves 35 and 36, towards first guide sleeve 35 and then moves armature 20 with valve needle 3 and first guide sleeve 35 in the stroke direction against the spring force of return spring 23. In this operation, valve needle 3 takes second guide sleeve 36 with it in the stroke direction. Guide sleeve 36 may be welded to valve needle 3. Valve closing member 4, which may be acted on by valve needle 3, lifts off valve seat surface 6 and fuel may be sprayed out through spray orifice 7.

When the solenoid current is switched off, after a sufficient decay of the magnetic field, the armature 20 drops away from the internal pole 13 in response to the pressure of return spring 23, as a result of which the unit composed of valve needle 3, stop sleeves 35 and 36 and armature 20 moves against the stroke direction. As a result, valve closing member 4 settles onto valve seat surface 6 and fuel injector 1 is closed.

Figure 2 shows the area identified as II in Figure 1, in a partial and highly schematized representation.

Armature 20 may be situated between first guide sleeve 35, upon which return spring 23 may be supported, and second guide sleeve 36. The central opening 34 in armature 20, the diameter of which may be selected to be slightly greater than the diameter of valve needle 3 which protrudes through armature 20, will ensure radial play for armature 20. Since between first face 37 of armature 20 and first guide sleeve 35 there may be a first gap 43, and between second face 38 of armature 20 and second guide sleeve 36 there may be a second gap 44, a slight axial play may also be present. Armature 20 may be accurately and precisely guided only by external pole 9 of fuel injector 1, thus external pole 9 in the present first exemplary embodiment may be sleeve-shaped. The sleeve-shaped component identified by 9 may also be a non-magnetic thin-walled sleeve which may be a part of the injector housing.

Guide sleeves 35 and 36, may be guided in internal pole 13 and in nozzle body 2 of fuel

injector 1, and in each case with a slight play. Guide sleeves 35 and 36 may be rigidly connected to valve needle 3, preferably by welding. This ensures on the one hand that the rotational symmetry of valve needle 3 is maintained, and also ensures problem-free guidance of valve needle 3 and/or armature 20, even in the event of serious center offset or major manufacturing errors in the components used.

Once the current exciting solenoid 10 is switched on, after sufficient creation of the magnetic field, armature 20 is attracted to internal pole 9. In this operation, armature 20 brings valve needle 3 with it, via first guide sleeve 35, against the force of return spring 23, and as a result fuel injector 1 is opened. Since first gap 43 is between first guide sleeve 35 and armature 20, armature 20 is initially pre-accelerated by the magnetic field, before the magnetic field has to exert stroke force in drawing armature 20, against the force of return spring 23. As a result, in addition to guaranteeing that armature 20 will move freely or that valve needle 3 will operate without tilting, the opening times of fuel injector 1 may also be improved.

Similarly, after the solenoid current is switched off, armature 20 is initially pressed away from internal pole 13 by return spring 23 and pre-accelerated via the stroke of second gap 44, before armature 20 takes valve needle 3 with it by second guide sleeve 36 and fuel injector 1 is closed. As a result, in addition to guaranteeing that armature 20 will move freely or that valve needle 3 will operate without tilting, the closing times of fuel injector 1 may also be improved. Overall, these measures also improve the accuracy of the fuel metering.

Figure 3 shows a second exemplary embodiment of fuel injector 1 according to the invention, from the same view as in Figure 2.

A further improvement of the guidance of free armature 20, in the present second exemplary embodiment, surfaces 39 and 40 of guide sleeves 35 and 36 facing faces 37 and 38 of armature 20 may be formed in a wedge or cone shape. Elevations 41 and 42 act as the corresponding abutment surfaces for wedge-shaped surfaces 39 and 40 of guide sleeves 35 and 36, elevations 41 and 42 may be formed in rotational symmetry with faces 37 and 38 of armature 20 and, for example, they may be formed as a truncated cone, a crown or a spherical cap.

Elevations 41 and 42 formed in this way may be keyed together with wedge-shaped surfaces

39 and 40 and thus ensure more precise guidance of valve needle 3 in guide sleeves 35 and 36, without restricting the free movement of armature 20 or the rotational symmetry of valve needle 3.

Since the total axial extent of gap 43, 44 may be smaller than the height of the keyed connections, armature 20 cannot escape from the hollows in wedge-shaped surfaces 39 and 40 of guide sleeves 35 and 36. As a result, valve needle 3 cannot tilt or stick.

The invention is not restricted to the exemplary embodiments represented and may also be used for a large number of other fuel injectors, and in particular also for fuel injectors in which the opening action is outwards.